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Cables :: "Stomata." | Phone :: 2183

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LIVESTOCK IMPROVEMENT IN THE TROPICS.

IN contrast to farming in the temperate zones comparatively little attention has been paid to livestock problems in tropical regions. This is mainly because agricultural prosperity in the tropics is not largely bound up with the successful combination of crop and animal husbandry as it is in the temperate countries. Cattle are used chiefly for draught purposes and there has been little attempt to improve them as producers of meat and milk. Indeed, the lack of care bestowed in general upon any but working cattle is most regrettable. In view of the small part played hitherto by animals in tropical farming it was but natural for Colonial Departments of Agriculture to confine their activities almost solely to problems of crop production. In recent years, however, the situation in respect of livestock has changed materially. It has become quite clear that there are definite possibilities for the development of an animal industry in connection with systems of mixed farming. As tropical agricultural areas become more settled such systems, instead of being of rare occurrence, will become common, and the relationship between crops, stock and farmyard manure will thus be in much greater evidence than it is now. In many colonies, moreover, animals and their products are likely to take a much more important place in internal trade as a more commercial attitude is adopted by the native population towards their stock. There is already a demand in many tropical areas for fresh meat and milk both by Europeans and the native population which still has often to remain unsatisfied. It seems, therefore, that the future of those parts of the tropics which are not essentially concerned with the production of perennial crops will lie in an improved livestock industry.

Animal husbandry in the tropics is unfortunately still in its pioneering stage. It is true that quite a considerable amount of knowledge on tropical livestock has been accumulated in recent years by veterinary and agricultural officers but very little of this is yet available in published form. Such knowledge, however, is still much scantier than what is known about stock in the temperate regions. Yet the raw material available to work on in the tropics is very promising. It has already been shown

that by selective breeding indigenous breeds of cattle in tropical countries are capable of vast improvement in production. In West Africa, for instance, experience has demonstrated that once the annual period of starvation—which occurs under systems of native management—has been eliminated, growth becomes more rapid and animals mature at an earlier age and begin to breed more regularly. It has also been found that there are also great possibilities in selective breeding for milk as there exist distinct milking and non-milking strains in the indigenous animal population. In East Africa, experiments undertaken with the same objects in view have yielded similar results. Unselected native cattle, bought at random in the reserves showed great promise as producers of milk and dairy products when kept under controlled and regular conditions of management and, as in West Africa, matured very much earlier and grew very much faster. Good as these results are, it is very doubtful whether the experiments at present in progress are being carried out on the extensive scale which they deserve.

There are undoubtedly many ways in which livestock could be improved in the tropics. Whatever schemes are undertaken, however, it will not be possible to carry them out on true scientific principles until more knowledge is obtained of existing breeds. Theorectically, therefore, the first step should be to make a survey of all local indigenous livestock to ascertain "the distribution of each breed, the nutritional requirements at different seasons, the rate of growth, the breeding frequency, the milking capacity and quality on different diets, and, above all, the resistance to disease. The characters of each indigenous breed should also be surveyed before they become modified under the influence of a changed system of husbandry or the introduction of breeds from other parts of the world." Having made such a survey opinion is likely to differ as to whether improvement can best be achieved by the selection of pure strains of individual breeds, by crossing breeds to produce offspring retaining the good qualities of each, or by the introduction of foreign blood. Where there are very large herds of native stock the simplest measure of improvement is the castration of inferior males. Before embarking on a scheme of castration however, it should be decided whether the stock is to be selected for beef, milk or draught, since a breed potentially useful for one of these purposes may be spoilt by faulty selection. Different policies may be desirable in different parts of a single colony.

The possibility of improving indigenous livestock immediately raises the question of food supplies since, where livestock is concerned, "the degree of improvement must always be dictated by the plane of nutrition". Failure to take notice of this principle has often led to disappointment in attempts to grade up high class imported stock. Here again our knowledge of methods of stock management in the tropics is meagre. Even for the most commonly used tropical fodders and concentrated foods, digestibility coefficients derived from experiments with tropical animals in tropical countries are still generally lacking. So also are determinations of the maintenance and production requirements of tropical stock. Apart from using a few figures of this kind which have been ascertained and published in India, all one can do in regard to tropical animals is to make guesses based on figures that were derived from experiments with temperate climate breeds in temperate conditions, making guessed adjustments for the difference in average weights of the breeds. For many tropical foods that are quite commonly used no digestibility coefficients are available at all. Nor is it difficult to name foods and fodders which are regularly used in one tropical country, while elsewhere the same foods will be regarded as inedible or unpalatable for stock.

Other questions needing study are those of dairying, water supply, pasture management, and parasitical diseases, especially where it may be necessary to discover disease resistant breeds and to evolve new methods of control. It is known that generally in the tropics special precautions in regard to housing and/or regular treatment are necessary to protect stock against excessive infestation by intestinal parasites, skin diseases or similar troubles—troubles which make all the difference between profit and loss, even although they do not amount to rapidly fatal diseases. In respect of the more dangerous epidemic diseases, the agriculturist is greatly indebted to the veterinarian for the vast improvement in the situation that he has effected during the last 20 years; and indeed it is this progress which makes the prospects for the profitable development of livestock industries in the tropics at all possible.

We feel sure that while much information must await the results of scientific investigations that are not yet even planned or contemplated, yet there is in several colonies much reliable knowledge gained in recent years by trial and error which has never yet been published. We shall welcome the opportunity of considering for publication in this Journal any articles on these subjects likely to be valuable to our readers.

The tropics afford a fertile and practically unexplored field for livestock research and with the growing imporatnce of livestock in the general economy of tropical farming, it will be necessary to pay a great deal more attention to this subject than has been done hitherto. It is no exaggeration to say that the improvement of livestock and of animal husbandry must be an important factor in the future development and prosperity of a large part of the inhabitants of the tropical regions. Anything therefore which can be done to increase our present knowledge of tropical stock by the provision of more facilities for experimental work and by the study of the problems which we have outlined should become of permanent value to the Colonial Empire as a whole.

THE MANGO: A STUDY IN SYSTEMATIC POMOLOGY.

By Wilson Popenoe.
(*United Fruit Company*).

That branch of horticultural science known as systematic pomology—the classification and description of fruit varieties—has received scant attention in tropical America. The citrus fruits involving several species and many varieties, have come to us in the main from subtropical regions, well classified and described by students who have devoted long years to the subject. The avocado, because of the commercial importance it has recently attained in the United States, has also been placed upon a fairly satisfactory basis.

But with the great majority of tropical fruits the situation is different. Since few of them have been propagated vegetatively to any great extent, horticultural varieties have not been recognized nor established; and lacking horticultural varieties, there has been no need for classification and description.

This situation is changing—not as rapidly as some of us had hoped, but it is changing nevertheless; and the time will come when many tropical species will be propagated vegetatively for the commercial production of high-grade fruit, which to be acceptable to an exacting public must be uniform in character and marketed under recognized varietal names.

The mango, though known in tropical America mainly through the abundance of inferior seedling forms, is one of the truly great fruits of the world. In the Asiatic tropics, especially in India, it has been propagated vegetatively for centuries and many fine varieties are the result. These are in many instances imperfectly known pomologically. Their nomenclature is confused, and their classification has received attention only at the hands of a few scattered workers. This fruit, therefore, seems eminently suited for a study of the possibilities of systematic pomology in the tropics, and it is proposed here to review the situation, not so much with a view to increasing the available information regarding mango varieties, and their classification, as to stimulating further interest in the general subject.

Nomenclature.

The basis of pomological science is sound and accurate nomenclature. As long as confusion exists regarding varietal names, as long as there is bewildering synonymy, as long as the same name is applied to two or more different varieties, there can be no classification nor description.

A pomological variety has been defined as "a group of plants propagated vegetatively from one original plant producing fruit of a distinctive appearance, texture, flavour or aroma, by which characteristics it may be distinguished from fruit of other trees of the same species." Once it meets these requirements, a variety should be given an appropriate name by which it can be distinguished from others of its kind.

Many years ago, the rules governing nomenclature of fruit varieties were codified by the American Pomological Society and generally accepted by horticulturists in the North. These rules have stood the test of time, and have been found useful in developing a more appropriate and convenient nomenclature. There seems to be no reason why they should not be followed in the tropics. Succinctly stated, they are these: in choosing names for new varieties, distinctiveness, simplicity, ease of spelling and pronunciation, and indication of origin or parentage are all points to be kept in mind. Varietal names should consist of a single word, and the use of a number either singly or attached to a word, is to be tolerated only as a temporary expedient. The use of such terms as "seedling" and "hybrid" is not considered admissible, neither is the use of a possessive noun.

The mango varieties propagated vegetatively and cultivated in the West Indies at the present time are fortunately not so numerous as to present any serious problem from the standpoint of nomenclature. We have, for example, Julie, and Haden, and Pairi, all simple names conforming in every respect to the Code (though there is some confusion with regard to the correct spelling of Pairi); but the situation in the Asiatic tropics seems quite different. Such names as "Fernandino No. 2", "Phillip's", and "Banchore of Dhairey" are to be found in the literature.

Obviously, it is no easy matter to alter a name which has been in use during a long period of time. The lesson we must learn is to avoid in the future the mistakes of the past, and keep the subject as free as possible of the complications which result from the use of compound names, numbers, and words difficult of spelling or pronunciation. Indian literature on the mango has been particularly characterised by illogical orthography and many variations. For example, one and the same variety is listed as Pairi, Pirie, Peary, Pyrie and Paheri. And again, the variety Khirsapati occurs as Kheershapottee while Kilimuku is spelled Killeemookoo. Most of these difficulties are due to the transliteration of native names into English. In such cases, satisfactory solution is attained by having the names written in native character by an educated native, then transliterating them on the system adopted by the International Congress of Orientalists at Geneva in 1894; which is, that consonants are given their value as in English, vowels as in Italian.

Classification.

The object of classification is, or should be, to bring together all those varieties which have several important characteristics in common; in other words, those which presumably are related by descent from a common ancestor. Opposed

to this Natural System, as it is termed, is the arbitrary or artificial classification often employed in cases where information is still wanting on which to base a natural classification. In the early days of avocado culture, for example, it was no uncommon thing to see varieties classified in such groups as these: (1) pear-shaped, green-fruited varieties; (2) pear-shaped, purple-fruited varieties; (3) round, green-fruited varieties; and so on. Such a classification has little value when compared with the one in use at present, namely, the grouping of avocados in three races, the West Indian, the Guatemalan, and the Mexican, each of which has several important characteristics common to all its members, and distinct from those of the other races.

Races, it should be stated, are such broad general divisions that individuals breed true when grown from seed, so far as the racial characteristics are concerned. While the mangos of the world have not yet been thoroughly studied from this standpoint, investigation of the seedlings growing in certain parts of tropical America has led to the belief that numerous well-defined races do exist. The origin of these races is lost in antiquity. Some of the evident differences may in fact be the result of derivation from more than one species of *Mangifera*. Particularly do the mangos known in Cuba as Filipinos, and those of the Cambodiana class in Florida (a group introduced from Indo-China some forty years ago) appear so distinct from others that botanical rather than horticultural characters seem involved.

The problem of defining the seedling races is broader and probably more important than that of classifying the horticultural forms propagated vegetatively. Work on the latter subject can if necessary be confined to the varieties present in any given region. It has in fact been attempted in India, in Florida, and probably a few other places. When engaged on mango investigations for the United States Department of Agriculture many years ago, the present writer attempted a classification of the principal varieties then growing in Florida (cf. "The Natural Groups of Mangos Cultivated in Florida", *Proc. Am. Pomological Soc.*, 1917) based wholly on what appeared to be natural relationships. This was later used in his "Manual of Tropical and Subtropical Fruits" (Macmillan and Co., 1920) and seems to have proved satisfactory, though admittedly it is by no means perfect. In forming this classification of natural groups (Mulgoba, Alphonse, Sandersha and Cambodiana), growth characters, leaf characters, the inflorescence, and the fruit were all taken into account; and though differences in some cases were so slight that they were not evident to the casual observer, familiarity with a large number of varieties in the field resulted in a final conviction on the part of the writer that the relationships were real. A similar study of the mangos of the West Indies is suggested.

Description.

If nomenclature is the basis, accurate and complete description is the essence, of systematic pomology. In general, it seems fair to state that the tropics still lag far behind the temperate zone in regard to the quality and uniformity of descriptive work used in defining pomological varieties. Next to vegetative propagation itself, it is sincerely believed that there is nothing which will do more to advance the cause of fruit growing in the tropics than detailed attention to this subject.

For this reason, and with no pretence of having developed a descriptive technique for the mango which admits of no improvement, the writer takes the liberty of reproducing from the *Proceedings of the American Pomological Society*, 1913, the following outline of the procedure to be followed in making a technical description of a mango variety. Such a description, be it remarked, greatly facilitates the identification of fruit specimens and the placing of a variety in its appropriate natural group:—

"In describing a variety, the *General Form* of the fruit should be stated first. It may be reniform, subreniform, oval, oblong, elliptical, spherical, &c. Often it is asymmetrical. Frequently a combination of two or more terms is needed; indeed, some mangos are of such peculiar form as almost to defy accurate description. In cross section the fruit is usually round, oval, or elliptical.

Size.—As the mango is so little-known pomologically, each individual usually has his own ideas as to what constitutes a small, medium, or large fruit, hence the use of such terms is not always satisfactory. They should in any event be supplemented by the dimensions and weight. The dimensions necessary are length, breadth and thickness. Breadth is taken dorso-ventrally, it being an easy matter to determine the ventral surface of the fruit by the location of the "nak" or stigmatic area, which is always to the ventral side of the apex. Care must be exercised to get each measurement in one plane only.

The *stem* must be described with regard to its insertion—square or oblique. One should also mention its length, and whether it is stout or slender.

The *base* is commonly rounded, flattened, or tapering. The "shoulders" form an important character, and are distinguished as ventral and dorsal. They should be described as to prominence. Often one is entirely wanting, sometimes both. Rarely are they equal in prominence.

The depression around the insertion of the stem forms the *cavity*. It is sometimes wanting, the base of the fruit being extended where it joins the stem. The cavity should be described as to form, depth, breadth, and markings. The form may be obtuse, acute, or acuminate, and while usually regular, the cavity is sometimes furrowed or plaited more or less deeply. The

depth may be shallow, medium deep, or deep; breadth from narrow to broad; the markings, if any, are in the nature of russeting or distinctive colouring.

The *apex* is commonly obtuse, rounded, or acute; sometimes more or less prominently is hooked or "beaked". The stigmatic point is situated close to the apex on the ventral side of the fruit and is known as the "nak", a Hindustani term probably first used by Maries. It may consist in a slight prominence or a slight depression; its height or depth should be stated, together with its distance from the longitudinal apex of the fruit.

The *surface* should be described as to smoothness and next as to colour. By colour is meant the ground colour of the skin, aside from the colour of the dots or blush sometimes present on the cheek, which should be described separately. The dots, most of which are usually subcutaneous, should be described as to size, colour, form and abundance. The colour and thickness of the bloom should also be stated.

The *skin* should be mentioned as regards thickness, texture, and adhesion to the flesh.

The *flesh* should be described as to colour, texture, aroma, and juiciness. One should also mention whether it is scant or abundant. The amount of fibre present should be stated, as well as its coarseness or fineness. In some varieties the fibres are confined to the ventral edge of the seed and do not extend any great distance into the flesh.

The *flavour* is a point often difficult of description. Nevertheless, a fairly accurate idea may usually be given by the use of such terms as acid, subacid, sweet, aromatic, spicy, mild, rich, melting, and the like.

Quality.—A careful attempt should be made to estimate the general quality of the fruit, which is described by the use of such terms as poor, good or excellent.

The form and size of the *seed* should be carefully described, and the weight, as well as longitudinal, transverse, and lateral dimensions given. Further, in the light of the recent important discoveries regarding the embryony of the mango, it should be stated whether the seed is monoembryonic or polyembryonic.

The *season* is usually described as early, midseason, or late; but it is well to add the exact period during which, in each particular region the fruit can be picked; also its keeping and shipping qualities.

There are usually a few *remarks* regarding the fruit which will suggest themselves, and which have not been provided for in the general description. These should be noted down, following which the *characteristics of growth and productiveness* should be fully described. Under this head will be included any peculiarities of growth or foliage, resistance to cold or disease and those most important of points, precocity and regularity of bearing, as well as the average size of the crop.

The importance of accurate illustrations to accompany the description of each variety cannot be overestimated. If photographic apparatus is not available, careful drawings will suffice. One drawing should show the general outline of the fruit, another a longitudinal section with the seed in place, and a third the seed alone, viewed longitudinally."

While the above outline applies solely to the mango, the sequence in which characters are treated, and the general method of treatment, are those which are used generally in pomological description. Eliminating one or two of the characters (*e.g.* the beak, which is a feature unique with the mango) and substituting others—but not altering the sequence—some such form as this should be used in describing fruit varieties generally.

In the temperate zone, interest in systematic pomology seems slightly to have waned during the past quarter of a century. The excellent examples of pomological description—many of them prepared by that master of the subject, William A. Taylor—which appeared annually in the Yearbook of the United States Department of Agriculture during a period of many years, have been discontinued. So far as the north is concerned, perhaps the need for such work is not so great now as it was in earlier days. But it is the writer's firm conviction that the tropics, where fruit growing is only now commencing to emerge from the dooryard stage (excepting of course with regard to such crops as citrus and bananas), can gain much from detailed study, along the lines suggested above, of the pomological materials so abundantly at hand.

STORING COFFEE SEED.

Experiments are described in *Bergcultures*, 1939, 13: 1506-12, from which it is concluded that in Java, by taking certain precautions, good germinating coffee seed can be made available at any time of year. Reactions to storage vary with the clone, some varieties losing their germinating power sooner than others. The moisture content of the beans affords an indication as to their storage quality though resistance to low moisture content is variable. In no variety could germination be obtained if the moisture content was lower than 25 per cent. The germination of *arabica* was least affected by a low moisture content while some *robusta* varieties were found to dry up more quickly than others in similar storage conditions. Disinfection of six months stored coffee seed by the turpentine method had no harmful effect. The turpentine method consists of superimposing 5 cm. thick layers of coffee seed between single layers of cloth impregnated with turpentine and keeping them there for four days. The containers are boxes 65 x 75 x 70 cm. An increase in germination of 30 per cent. but no increase in duration of viability was obtained by treating the seed with 1/100,000 tri-indole-acetic acid. Treatment with Belvitan, a proprietary growth substance, had no result.

AN ECONOMIC SURVEY OF RICE FARMING IN WEST DEMERARA.*

By H. D. Huggins, M.Sc., Dip. Agr.
(*Agricultural Economist, Dept. of Agriculture, British Guiana*).

Need for reliable information.

It is difficult to find an occupation in which so much individualism prevails as in farming. The amount of help which a farmer has or can pay for, the distribution and size of his farming enterprises, the variety of crops grown all result in differences in practice even among neighbours. Some of these practices are profit yielding, others are not. If this be admitted it follows that it should be helpful to find out what exactly are the agricultural practices and the economic status of the farmer in a given district, and how the practices of the most successful farmers differ from those of the least successful. It does not seem possible to embark with assurance, on a planned policy of agricultural education in a district, or to establish land settlements or schemes for assisting and organising farmers, without the aid of such basic information which can be of service not only to the agriculturist but to the Medical, local Government, and other Departments of Government.

Having decided that information of this type is desirable, one must be cautious about the method of its collection, because it is not easy to determine by superficial examination what is the cause of success or failure in farming. For example, one might attribute the success of a farmer to the price he obtains for his milk, when in reality his cattle are not paying at all; the dilapidated appearance of a farmstead may be ascribed to bad farming, when the real cause is a large family; a newly painted cottage is often the result of a thoughtfully arranged marriage or of some enterprise unrelated to farming.

In this study the survey method of collecting information was used, being relatively cheap, quick and most practicable in a community not literate enough to keep records. It sometimes happens that a farmer prefers not to give the information asked for and he refuses, but it rarely happens that he forgets; the crop season asked about is too recent. The literacy of a farmer matters little, for it is the experience of all those taking part in this survey that the rice grower, who can neither read nor write, remembers the details of his last crop as readily as do others. A difficulty greater than the farmer's ability to remember is his suspicion of these intimate questions regarding his private business. The experiences in the early stages were so similar to those described in a recent survey carried out among small farmers in India that a section of the report is quoted: "The villager is always suspicious especially when the Government tries to enquire into details regarding his domestic affairs, and it is difficult to convince him that the enquiry is being conducted for his own good."

Area studied.

British Guiana lies on the north-eastern coast of South America and is divided for administration purposes into three counties—Berbice to the east, Essequibo to the west and Demerara in the middle. Running through Demerara and dividing it into two parts is the Demerara River. It is on the western part—usually called 'West Demerara'—that this survey has been conducted to make a study of the rice farming settlements of Vreed-en-Hoop, Nouvelle Flanders, L'Union, Rotterdam, Haarlem, Ruimzigt, Windsor Forest, La Jalousie and Hague.

The area covered was approximately 8 miles in breadth and 4 in depth and the data reveal some marked differences between the organisation in the eastern section (near to the city of Georgetown and including Vreed-en-Hoop, Nouvelle Flanders, L'Union, Rotterdam and Haarlem), and the western section (including Ruimzigt, Windsor Forest, La Jalousie, Hague).

Practically all of the agricultural development occurring in British Guiana has taken place in a relatively narrow strip extending along the coastland and for some distance up the banks of the main rivers. Most of this area is below sea-level at high tide, possesses no natural drainage and, as a result, has been brought into cultivation at considerable expense. This charge, over and above that necessary for normal internal drainage, does not arise in a naturally drained country and is so substantial that it has mainly been met, in the first case, by individual proprietors in the days of slavery and by sugar plantation companies rather than by farmers.

This general description holds good in the present instance; it was only after the critical period through which sugar passed at the end of the last century that owners were forced to dispose of their properties and the sugar plantations came to be converted into the rice settlements which are the subject of this study. When the sugar companies sold, the purchasers maintained their new properties on a plantation basis in regard to irrigation and drainage control but subdivided the old cane fields into small lots. These lots were then let to tenants and it is on this landlord-tenant basis that practically all of the rice is grown, not only in the area under investigation, but in British Guiana as a whole.

* This survey is the second of a series of economic studies which have been instituted by the Director of Agriculture, British Guiana, and with whose authority it is published. The first of this series was published in *Agricultural Journal, British Guiana*, Volume VIII, No. 3.

A legacy from the sugar estates is an efficient irrigation-drainage system which is largely responsible for the high rice yields obtained. Although the annual rainfall is about 93 inches per annum, and the early growth is timed to take place in the rainiest months of the year dependence is not only on direct rainfall. The Boerasirie Service Canal together with the level nature of the land enables irrigation to make the supply of water satisfactory in most years; this is especially so in the case of the Autumn or mid-year crop.

The average rice farmer performs the necessary cultural operations with the aid of his family and hired help at planting and reaping. He rarely disposes of his crop as unmilled rice or padi, considering it more profitable to pay a milling fee, and to sell his crop as milled rice. It is of interest that in certain other rice-growing areas of the Colony, more distant from a market centre, the grower seldom mills his rice but normally sells it as padi.

The farmers in West Demerara, as farmers in other parts of the Colony, reside not individually on their several farms but communally in settlements. Certain considerations appear to have operated in evolving and thereafter maintaining this system. The two chief peoples engaged in farming came originally from India and Africa, in both of which countries the advantages of mutual protection were of such importance that communal settlements became a firmly established practice. The necessary drainage and irrigation operations cannot be maintained by individual action. The front lands which have been chosen as sites for settlements offer many advantages from the point of view of health conditions in general and malaria in particular. The absence of a good foundation and natural metal has made the building of roads costly and difficult in British Guiana; the lack of inter-communication would inflict on scattered homesteads difficulties relating to children's education, medical aid, social activities, work off the farm.

Outline of work done.

The crop-year studied began with the 1937-38 'Small', or Spring, Crop and ended with the 1938 'Big', or Autumn, Crop, *i.e.* approximately November, 1937 to October, 1938. No farm was selected for study unless it was regarded as comprising a single farming unit and unless it was big enough to form an important enterprise and source of income of some individual resident in the area covered. On each of these farm units rice was one of the enterprises. Records were secured from 568 such farms but after certain were discarded, for which the data were incomplete or appeared unreliable, there were left 509 records which form the subject of this study. Every effort was made to ensure that this sample fulfilled the requirements necessary for being regarded as random. Further, the sample taken in the survey represents over 50 per cent. of the total farming population; the conditions described may thus be accepted as typical of the area.

In 1936 a survey was conducted in a cane-farming area in East Demerara; the present survey has been carried out among rice farmers in West Demerara. These two areas, if judged by appearance, may be considered among the most successful farming areas in the Colony, cane-farming being the major enterprise in the one, rice-farming in the other; West Indians preponderate in the one, East Indians in the other. When it is considered sufficiently interesting, attention is drawn to differences or associations in the farm organization in the two districts surveyed.

The farm business and its organization.

The average investment per farmer is $384 (Table 1); this is more than twice that of the average cane farmer in East Demerara. Such a difference might not have been anticipated since in East Demerara a large proportion of the farmers own the land they cultivate, which in the rice areas under discussion few farmers do. But land is relatively cheap in British Guiana and there are other factors which appear to explain the higher capital in the rice farming area.

(1) In West Demerara, the livestock used for ploughing, transporting and threshing, are owned by rice farmers; in East Demerara the mules employed for transporting farmers' canes are owned by the grinding estates, not by farmers. Dairy cattle play a bigger part among the rice farmers in West Demerara than in the East Demerara villages, and cattle are relatively expensive articles of equipment.

(2) A higher percentage of farmers own their own houses in West Demerara than is the case in East Demerara—88 per cent. and 80 per cent. respectively.

(3) House lots are more expensive in the Windsor Forest than in the Vreed-en-Hoop area.

Table 1.

Average Rice Farm Organisation in West Demerara.

Item.	Units.
Average	
Capital per farm ($)	384±16
Receipts per farm (excluding Home Consumption) ($)	314±11
Receipts per farm (including Home Consumption) ($)	348±11
Expenses (excluding unpaid labour) ($)	170± 8
Expenses (including unpaid labour) ($)	215±10
Farmer's Earnings ($)	114± 4

(4) In the cane farming survey West Indians preponderate; in the rice farming survey practically all of the farmers are East Indians. In all branches of business in this Colony the East Indian consistently shows himself to be more successful in accumulating wealth than the West Indian.

Over the area as a whole, farmers invest about 74 per cent. of their capital in house and land, about 23 per cent. in livestock and about 3 per cent. in boats, tools, &c. (*See* Table 2.)

There is a real and big difference between the money in livestock at Windsor Forest and Vreed-en-Hoop; judged on a value basis, the average rice farmer's livestock enterprise at Vreed-en-Hoop is more than twice as important as at Windsor Forest.

The average receipts per farmer, including products consumed on the farm and money earned off the farm, were $348. (*See* Table 3.)

At Windsor Forest rice is responsible for 60 per cent. of the receipts while only for 48 per cent. of the receipts at Vreed-en-Hoop, but on the other hand, livestock supply 25 per cent. of the receipts at Vreed-en-Hoop and only 12 per cent. at Windsor Forest.

The average expenses, including unpaid family labour, were $215 per farmer.

The average rice farmer in the area studied is a tenant, practically all of the lands being owned by large landed proprietors or by Government. Taxes are therefore not a very important charge and are less than 1 per cent. of the farmer's gross expenses. The average tax paid per farmer at Vreed-en-Hoop ($2.33) is higher than at Windsor Forest, where it is only $0.57. Rents are, however, a much more substantial figure and constitute 13-15 per cent. of the farmer's expenses, the average farmer paying $28.71 per annum at Windsor Forest and $42.72 at Vreed-en-Hoop. In return for the rent the landlord is expected to provide the land and to keep the main irrigation and drainage services in order.

Table 2.

Distribution of Capital.

Property owned.	Whole Area.		Windsor Forest.		Vreed-en-Hoop.	
	Average Investment. $	Total Investment. %	Average Investment. $	Total Investment. %	Average Investment. $	Total Investment. %
Buildings and House Lots ...	224±11	58	215±11	60	257±29	53
Land	63± 5	16	64± 5	18	57±14	12
Livestock	87± 4	23	69± 3	19	156±14	32
Tools, Boats, &c. ...	10± 1	3	9± 1	3	14± 2	3
Total	384±16	100	357±16	100	484±48	100

Table 3.

Distribution of Receipts Including Home Consumption.

Sources.	Whole Area.		Windsor Forest.		Vreed-en-Hoop.	
	Amount Received. $	Total Receipts. %	Amount Received. $	Total Receipts. %	Amount Received. $	Total Receipts. %
Rice	195±7	56	188±8	60	221±13	48
Other Crops	13±1	4	13±1	4	13± 4	3
Livestock	55±4	16	38±2	12	117±13	25
Labour on Estate ...	17±1	14	18±1	15	10+ 2	13
Labour otherwise ...	33±3		28±2		48± 9	
All Sources ...	348±11	...	316±11	...	464±29	...

Even though the proportion of rent to total expenses may be considered high, the observer gets the impression that the existing arrangement—tenantry—has certain advantages over ownership. Rice is a crop for which the control of water is important, and, if the grower's land is freehold, it would not always be easy for the public services to be submitted to the measure of control which is at present the case. There are, however, many who hold that peasant proprietorship is preferable since the same degree of supervision could be provided by a strong local authority. The problem is one on which there are strong convictions and is likely to receive prominence if and when rice farming areas should be extended by land settlement schemes.

The average size of a farm in the Windsor Forest section is 4.39 acres and at Vreed-en-Hoop 6.66 acres. The smaller size of farm in the Windsor Forest section is found to be due to some extent to the much smaller area cultivated at Hague, where residents depend more largely on employment by the adjoining sugar estate (Cornelia Ida). Further, there are fewer working oxen per farmer in the Hague area.

The rice grower handles an area more than twice as large as that of the cane farmer; some of the factors which seem to be associated with this difference are:—

(1) The rice farmer ploughs with oxen and lands are soaked to permit of this; the cane farmer handforks his land. As a result, the individual in rice farming can, with his family, handle more land.

(2) With cane farming, the cash outlay for paid labour would have to be much greater. Hence more credit would be required by the bigger cane farmers than by corresponding rice farmers; there is a widespread system of credit to farmers in rice-growing areas.

(3) There is a quicker turn-over with rice which reduces problems connected with financing, &c.

(4) Planting is easier in rice; seedlings are distributed by boat and all of this work can be done by women and boys. Transportation, distribution and planting of cane tops are adult occupations.

(5) The cane crop is a bulkier one to handle at harvesting time. The cane farmer must handle about 18 to 20 tons of cane from his acre, the rice farmer only about 1-1½ tons of padi per acre per crop.

(6) The cane farmer has more employment available off the farm and his business generally is based on a part-time farmer, part-time wage-earner outlook.

(7) The cane farmer gets slightly higher returns per acre of cane (about $40.00) than does the rice farmer from an acre of rice (about $37.00).

The farmer cultivates approximately the entire rice acreage under his control for the Autumn, or "Big", Crop and about 90 per cent. in the Spring, or "Small", Crop. The indication is that most of the land is being worked severely and only in rare instances escapes two crops yearly.

The average yield per acre, for Windsor Forest and Vreed-en-Hoop combined, is 20 bags or 2,800 lb. of padi in the Autumn Crop and 12 bags (1,680 lb.) in the Spring Crop, totalling 4,480 lb. per acre for the year. The yields are highest at Vreed-en-Hoop, next best at Windsor Forest and poorest at Hague.

In the Autumn Crop, farmers sow their seed in nurseries and transplant; the average amount of seed used is between 65 and 70 lb. per acre. This is approximately twice as much as recommended by the Department of Agriculture.

Crops other than rice receive little attention in the West Coast rice area; this is particularly so at Vreed-en-Hoop. The majority of the rice farmers at Windsor Forest and Vreed-en-Hoop derive, in each dollar of farm receipts, less than three cents from crops other than rice.

Of the farmers at Windsor Forest 97 per cent. and at Vreed-en-Hoop 99 per cent. keep livestock of one type or another, while only 86 per cent. at Hague do so. The average for the East Demerara cane farming area is 81 per cent. One of the chief reasons for the bigger livestock enterprise at Vreed-en-Hoop is the proximity of Vreed-en-Hoop to the city of Georgetown. Although Vreed-en-Hoop is on the opposite side of the Demerara River, an important fresh milk business has been built up, due mainly to the fact that connection is made with early ferries (6.00-7.00 a.m.). Windsor Forest is 5 miles further away than Vreed-en-Hoop and the first railway-steamer connection is made with Georgetown at 9 a.m.; although most of the milk shipped to Georgetown from Windsor Forest travels by motor car, transport to Georgetown for the early morning milk trade is not as easy or as cheap from the Windsor Forest as from the Vreed-en-Hoop farm. In addition, the pasture facilities at Windsor Forest need improvement.

Working oxen play an important part in the cultivating, transporting, and threshing operations. At Vreed-en-Hoop eight out of ten farmers, at Windsor Forest seven out of ten, and at Hague between four and five out of ten keep working oxen. There is a very consistent relationship between working oxen per farmer and acres per farmer. It is also indicated that the area handled by the farmer is influenced not only by the number of working oxen which he owns, but also to some extent by the number of oxen kept by his neighbour. This situation is understandable because in a small rural area with its intimate social and family ties, the farmer who has oxen will almost inevitably be called upon to share their services with his less fortunate

friend or kinsman. In the interest of himself and his neighbour, the rice farmer should be encouraged to own a minimum of one pair of working oxen. On the average, when a farmer owns less than two oxen he cultivates under three acres, when he has two or three oxen he cultivates five acres. The prospects of a farmer with three acres and one with five acres are significantly different.

Farm earnings and how they are made.

The difference between total farm receipts (including products from the farm consumed) and total farm expenses (including unpaid family labour and a five per cent. interest charge on capital) was $114. This means that during the year covered by the study, the average rice farmer earned about $114 or $2.20 per week, in addition to having a homestead in which he and his family lived.

About six out of every ten farmers made earnings of less than $2.31 per week; about three in ten made $2.30-$4.60 per week (Table IV). About one in ten made $4.60 and over per week. Thus in the same area there are farmers making about $2.20 and others making nearly $5.00 per week; these are big differences. There is no significant difference between the average earnings of a West Demerara rice farmer and an East Demerara cane farmer.

Table 4.

Variation in Farmer's Earnings According to Villages.

Farmer's Earnings. $	% Total No. Farms.	% Farms in Windsor Forest.	% Farms in Vreed-en-Hoop.
Loss ...	6	4	12
0-120 ...	55	58	45
120-240 ...	31	30	34
240 and over	8	8	9

As capital is to some extent a measure of the size of the farm business, there is often found to be an association between the amount of money put into a farm and the earnings made. Nevertheless, as the homestead represents a high proportion of the farmer's investment at Windsor Forest and Vreed-en-Hoop, capital is unlikely in the present study to be as sensitive a measure of the size of business as it sometimes is. In spite of this drawback, relationship between capital and earnings is well defined at Windsor Forest. Thus, the earnings of farmers having over $360 in capital is significantly higher than those in any of the lower capital groups.

The association between size of business (as measured by receipts and expenses) and profits is well defined especially at Windsor Forest where the type of farming is not as complex as that at Vreed-en-Hoop. In both sections, however, it can be emphasised that, in regard to receipts especially, farmers with the relatively large-sized business make better profits.

The conclusion that increasing the size of a farm business pays may appear self-evident, but there is, in practice, not as complete agreement on the point as may be thought. Many a farmer maintains that the small farm business is to be preferred. Those who hold this view argue that whatever income is made by a small business all comes into the home, that the less outside help to be paid—and to be watched—the better. They support this by pointing out that the large landowner plants little or no rice but finds it preferable to let his land to small tenants, and this is suggested as added proof that under existing circumstances there is a point beyond which it is not expedient to increase the size of the rice farm unit.

These are sound arguments and that there is a point beyond which it is unwise to increase the size of the rice farmer's business is not questioned; this survey does indicate strongly, however, that the average farmer, at Windsor Forest especially, has not yet reached that point. The size of his business should be expanded further.

The relationship between the size of farm and profits is shown to be one of the important associations indicated in this survey, but is not the same in application at Vreed-en-Hoop and at Windsor Forest. In the case of Windsor Forest, a factor which stands out is that, in order to increase his chances of higher profits, the average rice farmer should be encouraged to increase his area to at least four acres; his chances would be further improved if he could get his farm up to six acres and it could be pointed out to him that 28 per cent. of his neighbours have farms of this size.

At Vreed-en-Hoop, where livestock plays an important part, the relationship between acreage and profits is not clearly defined and there is no significant difference between the earnings of farmers with a small or large acreage.

The association between yields and profits indicates that the yield per acre obtained by the farmer is one of the important influences affecting the farm business.

It is evident that variety work, in spite of what has been done, will repay sustained and increased emphasis; need for this is seen in the fact that although yield per acre is one of the most significant factors affecting the farmers' earnings and that in consequence the variety planted is likely to be important, yet at Vreed-en-Hoop the majority of the farmers plant one variety and at Windsor Forest, just five miles away, a different variety is favoured.

Miscellaneous crops are too unimportant in the rice farm organisation to have a significant effect on earnings.

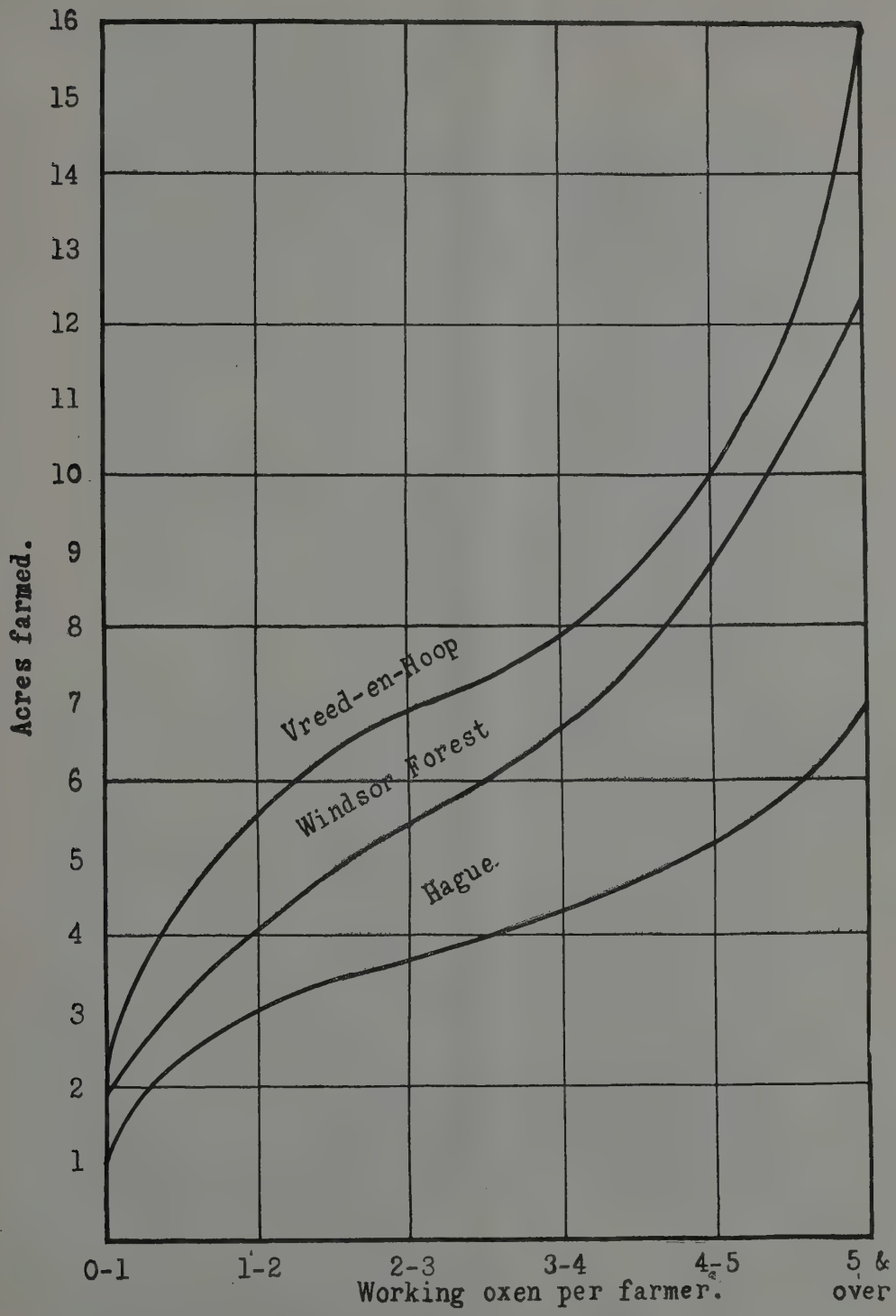

FIG. 1.—Regression lines showing relationship between number of working oxen owned by a farmer and size of farm which he is able to handle.

FIG. 2.—Planting of rice is done almost entirely by women, for whom the seedlings are pulled and transported by men. In sowing their nurseries farmers in West Demerara tend to use too much seed.

FIG. 3.—Part played by oxen in preparing land for planting is one reason for their significance in the farm business.

FIG. 4.—A pair of working oxen enables the average farmer, with the aid of his family to handle his fairly substantial amount of transportation. Practically all of this is done in boats such as the one shown.

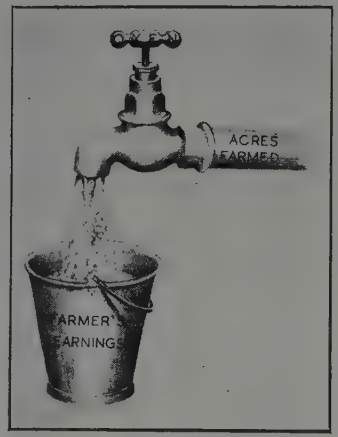

FIG. 5.—The inter-relationship of oxen, acres and earnings.

FIG. 6.—The rice mill (one shown in left background) has an important influence on the farm business. As indicated by his residence (right foreground) the miller is usually a person of financial standing.

FIG. 7.—Three mills at Windsor Forest within hailing distance of each other; not far away are eleven more. These compete for the farmer's milling business and, to encourage planting, willingly provide crop advances.

There is an indication that, in the area in the period under review, the chances of making attractive profits are increased but so also are the chances of losing as the livestock enterprise grows in importance. The farmer who specializes in his rice crop may be said to be 'playing safe', because livestock, while holding out hope for attractive earnings, seems easily able—whenever misfortune or mismanagement intervenes—to convert anticipated profit into loss.

The association between livestock returns and profits indicates in a general way that at Windsor Forest the average farmer's livestock enterprise may beneficially be extended; at Vreed-en-Hoop this is not the case.

Wages do not play the important part that they do in the cane farming area and the influence on the farmer's profits is not as clearly defined as in East Demerara.

It is interesting to note that there are some farmers in both areas who secure a substantial part of their receipts from wages earned off the farm; this group makes relatively high earnings.

Farm credit.

There is, in the area, a relatively large number of mills (22 from Vreed-en-Hoop to Hague) with keen competition, especially in the Windsor Forest section, for the handling of the growers' crop. In consequence, a farmer who is regarded as reliable has little difficulty in obtaining credit for crop production. So freely is credit provided that it is the general practice throughout the area for the miller to make crop loans, free of interest, provided he is guaranteed the grower's milling business.

Generally accepted as one of the small-farmer's major problems, crop financing is found to present no serious difficulties in the rice area of West Demerara and especially is this the case in the Windsor Forest section; of the 538 farmers asked to mention their chief farming problems, not one mentioned crop loans.

The farmer and his family.

There is a tendency for the farmer as he advances in age to develop his livestock enterprise. This is probably related to the fact that work with livestock is more suited to the inclination and physique of the older men. Another important consideration is capital, because, whereas a farmer can do a good deal of rice production with the labour of himself and family on rented land, livestock can be acquired only after money has been accumulated or property obtained with which to secure credit. If agricultural credit were more easily available it is probable that the livestock enterprise would increase in importance especially in the case of the younger farmers.

Although the differences in earnings of farmers in various age groups are not significant, it is interesting to observe that at Windsor Forest the farmer has his greatest earning power before he has reached thirty. At Vreed-en-Hoop, the farmer reaches the height of his earning capacity later, when he is between 30 and 40—at an age presumably when he has had time for his livestock enterprise to expand.

The average number of persons living in the farmer's house at Vreed-en-Hoop is about six, and at Windsor Forest about five. When he is 30 years old he has between three and four children alive. Out of every ten farmers' children working there are at Windsor Forest eight engaged in agriculture and at Vreed-en-Hoop five.

It is observed both at Windsor Forest and Vreed-en-Hoop that as farmers become more successful there is a tendency for their children to look to occupations other than agriculture; this was also found to be the situation among East Demerara cane farmers.

Approximately the same proportion of farmers is able to read at Windsor Forest and Vreed-en-Hoop—about one in every two. As a group, the illiterate farmers make smaller earnings and the difference is significant both at Vreed-en-Hoop and Windsor Forest.

The figures and the general attitude of farmers during the survey indicate that as long as a sales demand exists, extremely little milk finds its way into home consumption.

Races.

Rice cultivation is almost entirely an East Indian pursuit in this Colony. Of the total number of farmers studied only about four per cent. are not East Indians; and forms, in this random sample, were obtained from only 16 West Indians (3.7 per cent). There are various explanations given for the West Indian's distaste for rice production. It is said that he dislikes the long hours in water which rice work entails, that rice settlements do not depend on wage earnings to the same extent as cane and provision farmers frequently do, and that he prefers opportunities to make and spend money regularly.

Chinese do not participate much in agricultural production and formed but 0.61 per cent. of the rice farmers.

It is significant that little admixture of the races appears to be taking place. Although the villages are small and the residents have been living in close proximity for many years, only .25 per cent. of the farms in this survey are found to be of mixed Negro and East Indian origin.

Summary and Conclusions.

The report is given of an economic survey carried out in West Demerara, one of the well established rice producing areas of the Colony. Information was obtained in personal interviews

with farmers about the crop-year immediately completed. The work was carried out in a manner to ensure that the sample was random ; in addition an unusually large sample was taken. 568 farmers were interviewed and this is estimated as a sample of more than 50 per cent. of the farmer population of the area.

There are in the same area farmers making $2.20 per week and others $4 to $5. Attention is directed to some of the factors associated with these differences in farm earnings.

The Windsor Forest and Vreed-en-Hoop farm organisations have certain differences important enough to be given consideration in agricultural extension. At Windsor Forest rice has a predominating rôle. At Vreed-en-Hoop the farmer has a livestock enterprise more than twice as large as that of the Windsor Forest farmer, and big enough to have a considerable, if not controlling, influence on his profits. The average farmer at Windsor Forest has a livestock enterprise which is still small enough for him to be advised to try to enlarge it. Similar advice to the average Vreed-en-Hoop farmer would be unsound unless there should be some modification of the existing Vreed-en-Hoop farm organisation.

At Vreed-en-Hoop, where livestock play an important part, the relationship between acreage and profits is not clearly defined. At Windsor Forest, however, the issue is clear cut ; the farmer must plant more than four acres to increase his chances of making better profits.

Yield per acre of rice is one of the factors most definitely affecting profits.

The amount of seed padi in general use is about twice the amount recommended by the Department of Agriculture.

The number of oxen which a farmer has at his disposal has a very definite influence on his acreage. Since it has been shown that the size of the farm is one of the most important factors controlling the profits made, it is clear that the provision of working oxen is a major consideration in farm organization. If a rice settlement or other development scheme is being planned, facilities for pasturage and suitable breeding stock which will encourage the farmer to produce his own steers are likely to have a significant influence on the success of the scheme.

The area operated by the rice grower is twice that by the cane farmer. This is a consideration that may be significant should land settlement or development schemes be planned.

Generally, one of the small-farmer's major troubles, crop financing is shown not to be a major problem in the rice farming area of West Demerara.

There is a tendency (a tendency which was also noted in the East Demerara cane farming area) as the farmer becomes more successful for his children to look to occupations other than agriculture.

The health of the general farming area studied could probably be improved by educational work in regard to the use of milk. Milk, even when produced and sold by the farmer, is consumed to a very limited extent by his family.

Acknowledgments.

Constructive suggestions have been made during the course of this study and for these the writer wishes to express acknowledgment chiefly to Professor F. L. Engledow, Mr. C. H. B. Williams, Mr. R. R. Follett-Smith, Mr. E. B. Martyn, Dr. D. W. Duthie and Dr. G. Giglioli.

THE INORGANIC ELEMENTS IN NUTRITION.*

Extensive investigations made within recent years have demonstrated the importance to human nutrition of minute quantities of various mineral elements, and it is now known that at least thirteen inorganic elements are concerned with biochemical processes and must be provided in adequate amounts in the diet.

Calcium is one of the elements in which the human diet is frequently deficient, especially since the perfection of milling machinery which removes all the mineral-rich parts of the grain. The large fraction of the total food supply taken in the form of refined cereals and sugar (the latter being entirely free from mineral elements) puts upon the remaining portions of the diet the burden of supplying almost the entire inorganic needs of the body.

A certain parallelism exists between the utilisation of calcium and phosphorus by the body and the utilisation of iron. Calcium and phosphorus cannot be built into bone without the assistance of vitamin D, whilst the utilisation of iron by the system is impaired when the supply of ascorbic acid (vitamin C) in the diet is inadequate. It has been shown also that copper is important in connection with the utilisation of iron.

One of the most interesting mineral elements in its behaviour in the animal body is manganese. Deficiency of manganese in chickens produces a condition known as perosis which cripples the birds so badly that they usually die. Hens deficient in manganese lay eggs of very low hatchability, many of the chicks dying in the shell a few days before the time for hatching. When manganese is injected into the hens deficient in this element, the eggs hatch normally and produce chicks with normal bones. At present there is no evidence concerning the occurrence of manganese deficiency in human beings.

The cause of a blood disease in sheep and cattle known variously throughout the world as "Denmark disease", "coast disease", the "pines", "bush sickness" and "salt-sick" has been traced to cobalt deficiency. The animals suffering from the disease were found to have been grazing on pastures the soil of which was deficient in cobalt.

* Abstracted from an article in *Nature*, Vol. 146, No. 3707, p. 658.

BANANA CULTURE AROUND THE CARIBBEAN.

By Wilson Popenoe.

(*Concluded.*)

Planting.

Before planting the farm it is necessary to decide upon the spacing to be used and the number of plants which will ultimately be carried per mat. Since the spacing once established cannot be altered, it is highly important to give ample consideration to this matter in advance.

The spacing and pruning combination which best suits the individual case depends mainly upon two things :—

1. The number of mature plants per acre or hectare which the particular area can most profitably support ; and
2. The spacing between mats which will prove most convenient from the standpoint of tillage, or provision of adequate shade for suppression of grass.

The spacing of mats varies from country to country and even quite locally in accordance with individual ideas and needs. In Jamaica, planting is often done on poor soils 11 × 11 feet apart, and only one mature plant with its follower is allowed to each mat. On better soils, planting is most frequently 14 × 14 feet with two mature plants maintained in each mat. In Central America, 15 × 15 with three plants per mat is used on some of the heavier soils (where growth is not so vigorous as on sandy loams), while 16 × 16 with three plants and sometimes 18 × 18 with four plants is used on the richer soils.

In all these spacings the chief thing to keep in mind is the ultimate plant population per acre or per hectare. This is controlled by several factors, of which the most important is the fertility of the

Spacing and Pruning Combinations.

Square Planting.

Plants per Mat.	1		2		3		4		5	
	P/A.	P/H.	P/A.	P/H.	P/A.	P/H.	P/A.	P/H.	P/A.	P/H.
Spacing.										
10 × 10 Ft.	436	1,076	871	2,153	—	—	—	—	—	—
3 × 3 M.	450	1,111	899	2,222	—	—	—	—	—	—
11 × 11 Ft.	360	890	720	1,779	—	—	—	—	—	—
3½ × 3½ M.	330	816	661	1,633	—	—	—	—	—	—
12 × 12 Ft.	302	747	605	1,495	908	2,242	—	—	—	—
3½ × 3½ M.	330	816	661	1,633	991	2,449	—	—	—	—
13 × 13 Ft.	258	637	516	1,274	773	1,911	—	—	—	—
4 × 4 M.	253	625	506	1,250	759	1,875	—	—	—	—
14 × 14 Ft.	222	549	444	1,098	667	1,647	889	2,197	—	—
4½ × 4½ M.	200	494	400	988	600	1,481	799	1,975	—	—
15 × 15 Ft.	194	478	387	957	581	1,435	774	1,914	968	2,392
4½ × 4½ M.	200	494	400	988	600	1,481	799	1,975	999	2,469
16 × 16 Ft.	170	420	340	841	510	1,261	681	1,682	851	2,102
5 × 5 M.	162	400	324	800	486	1,200	648	1,600	809	2,000
17 × 17 Ft. ...	151	372	301	745	452	1,117	603	1,490	754	1,862
5 × 5 M.	162	400	324	800	486	1,200	648	1,600	809	2,000
18 × 18 Ft.	134	332	269	664	403	997	538	1,329	672	1,661
5½ × 5½ M.	134	331	268	661	401	992	535	1,322	669	1,653
19 × 19 Ft.	121	298	241	596	362	894	483	1,193	603	1,491
6 × 6 M.	112	278	225	556	337	833	450	1,111	562	1,389
20 × 20 Ft.	109	269	218	538	327	807	436	1,076	545	1,345
6 × 6 M.	112	278	225	556	337	833	450	1,111	562	1,389

P/A means Per Acre. P/H means Per Hectare.

land. In Jamaica, if poor soils are forced to carry more than 375 plants per acre the result is poor fruit; but these same soils if fertilized will maintain a hundred more plants per acre. In Colombia, it is considered that 550 to 575 plants per acre is about the optimum number. In Honduras and Guatemala, rich soils sometimes cannot carry more than 525, but usually 550; the heavier soils can carry 600 to 650. In Central America, a major objective in adjusting the plant population is to maintain sufficient shade to prevent the development of grass on the surface of the land, without, at the same time, allowing shade to become so dense as to interfere with normal development of the fruit. Under dense shade, bunches do not develop the compact form desired and fruit sometimes ripens on the tree before obtaining mature plumpness. In Jamaica, where implement cultivation is practised, control of grass through shade is not an objective, and plant populations are based wholly on the ability of the land to produce good fruit. For convenience of the planter the following table, showing populations which result from various spacings and numbers of plants per mat, is appended. It should be noted that this is based upon planting by the square system, though this is by no means the only one employed. In recent years, numerous planters have gone over to the hexagonal system, which results in approximately 15 per cent. more plants per unit of area, while maintaining the same distance between mats. Hexagonal planting—in other words, planting on equilateral triangles—is often confused with quincunx or "cinco de oro" planting; this latter, however, does not give the same population per acre.

The preparation of land for planting varies so greatly in different regions that it is scarcely practicable to treat of it here in detail. The simplest form is that practised in regions of abundant rainfall when clearing virgin forest for the development of banana farms. Underbrushing is followed by liming and staking. Holes about 18 inches wide and deep are then dug and the "seed" is planted in them. Large timber is then felled. Some months later, when the plants are six feet or so in height, the first cleaning is given with the machete.

At the other extreme is the method practised in Jamaica, where land is ploughed and harrowed before planting; irrigation laterals are installed and seed is placed in holes 18 × 18 inches in size, using, however, different propagating material from that commonly employed on new farms in Central America.

The question of propagating material is, in fact, one which merits more attention than is usually given it. Under favourable conditions of climate and soil, several different kinds of planting material will yield satisfactory results, providing (1) the quantity of rhizome or root tissue is not less than six or eight pounds, (2) it is not too old, and (3) it is sound. Speaking in general terms, it may be said that better results can be obtained with poor material if conditions of climate and soil are favourable, than is the case where these latter are not so good. In other words, a dry climate and poor soil demand better propagating material than a rich soil and a moist climate.

In Jamaica, it is the general practice to use nothing but entire "heads" from young suckers 8 to 12 feet in height. Heads from old plants which have matured their bunches of fruit are distinctly less desirable, as well as more unwieldy because of their large size.

In Central America, especially where new lands are being opened and transportation is difficult, it is customary to dig heads from large or mature plants, but not those which have produced fruit. These large heads are then cut into two or three pieces, each weighing eight or ten pounds, and bearing two or more eyes or buds which will develop into plants. This sort of propagating material is more economical than the type used in Jamaica, in that a greater number of "seeds" can be obtained from an acre of old plantings; and, where it has to be carried into the new farm on mule-back, the cost of handling is lower since the weight is less.

In Colombia, and occasionally elsewhere, sword suckers, three to six feet in height, are often used for establishing new plantings. Not only must these be handled carefully to avoid injuring them when moving them to the field, but there is the further disadvantage that they only produce one bunch of fruit in the first crop, whereas heads will often send up two strong suckers and produce two bunches in the first crop. The fact that sword suckers commonly produce larger bunches in the first crop than any other form of propagating material, does not wholly offset the smaller total number of bunches produced.

Cleaning and Tillage.

On rich soils in moist climates maintenance of a banana farm is reduced to its simplest and least expensive form. If the proper shade relation has been achieved, grass is kept under control and it is only necessary to cut down the broad leaved vegetation, which, even under shade, will often develop undesirably if not checked. This cleaning is done with a machete three to five times a year as conditions may require.

In Jamaica, Colombia, and to lesser extent in Central America, implement cultivation is practised, particularly on heavy soils under irrigation. There is also a certain amount of implement work in connection with preparation of land for planting. It has required the test of many years to determine which implements are best fitted for this work: indeed it cannot be said that all needs have yet been met to a degree which satisfies the banana man. The problem of ploughing for example: while animal drawn ploughs have largely been supplanted by tractor drawn implements, I personally have yet to see the plough which can be used in preparing an old

banana farm for replanting without considerable expense for clearing off trash and removing stumps. In recent years an implement has been devised to do this work which is proving highly satisfactory and which seems to have only one disadvantage—the initial cost is high. I refer to the over-sized disk harrow manufactured by the Rome Plow Company of Cedartown, Georgia, U.S.A. This harrow, known as the "Big Roman," comes in various widths up to 12 feet and has disks of the same size and strength as the largest disk ploughs. It requires 50 to 75 horsepower to pull it, hence the expensive nature of the complete outfit; but one of these harrows will go into an area of standing bananas and at one operation knock them down, turn them into the soil, and leave the latter in fine condition for replanting.

For maintenance tillage under Jamaican conditions, nothing has been found better than the medium weight Killefer disk harrow. Because of the close spacings customary on Jamaican farms and frequent turning required, it has been found that the five foot and six foot widths are the best. Under the somewhat rougher conditions of Honduras farms a heavier harrow such as the Rome Plow Company's disk ploughing harrow, six foot cut, is preferable.

The purpose of disk harrowing in Honduras and in Colombia is almost wholly the control of grass. In Jamaica, on the other hand, many soils require occasional tillage to keep them in good structural condition. In the irrigated area on the south side of Jamaica most farms receive eight to ten harrowings per year. This represents the maximum amount of harrowing given bananas in any country, so far as I am aware. It is supplemented in Jamaica by an annual ploughing of maintenance areas, given about August when most of the fruit has been harvested. On tough soils, the area immediately around the base of the plant is occasionally forked, since it is not reached by the disk harrow.

It would not be wise to leave this subject without emphasizing once more the importance of the grass problem in connection with banana cultivation, whether under irrigated or non-irrigated conditions. No banana farm should be expected to pay dividends unless grass is kept under control. The cheapest way to do this is by means of shade if other factors permit this to be used. It has been noted earlier in this paper that a shade canopy sufficient to dominate grass cannot profitably be maintained in such a region as the south coast of Jamaica. Where this is the case, the hoe can be used if labour is cheap; or the disk harrow, particularly on those soils sufficiently heavy to profit by occasional tillage. It is still a question as to how much damage is done to tropical soils, especially those subjected to heavy rainfall, through frequent tillage; just as it is a question how much tillage banana plants will stand before the damage done to their root-systems overbalances the gain from aeration of the soil. These are some of the problems which the individual planter must study for himself.

Manures.

Up to five years ago, very few banana plantations in tropical America received regular applications of artificial manures. Sporadic attempts had been made to introduce the practice in Jamaica and elsewhere, and Sodium Nitrate had been used occasionally in Central America to assist plants which were handicapped by grass or which had been temporarily injured by flooding or other causes.

A great change has recently taken place in this field. Instead of using artificial manures as temporary stimulants, it is now considered that there are many soils which need regular applications of these manures if they are to produce satisfactory yields of first-class fruit. Results have been particularly striking on the heavy clays of Central America and some of the heavy soils of Jamaica. It should be pointed out that there are still thousands of acres in production which do not require manuring. It should also be emphasized that one element, and one element only, is usually lacking to an extent which justifies the planter in spending money to supply it. This is nitrogen. I venture to assert that in nine cases out of ten the planter who needs to use manures will find nitrogen the only element which pays returns on his investment. Certainly, before spending money on potash and phosphoric acid, he should be very certain that his soils need these; and the only way he can be sure is through carefully recorded experiments, comparing the effects of these elements alone and in combination with nitrogen. Chemical analyses of the soil, which in the temperate zone have acquired great value because they are backed by exhaustive knowledge of the nutrient requirements of the various crops cultivated, are of relatively slight usefulness in the tropics where we do not yet have information with which to interpret them. The only safe and simple way for the planter to solve his manuring problem promptly, is to let the plants themselves tell him what they want.

Of nitrogen carrying manures which have been extensively used during the past few years Sodium Nitrate, Ammonium Sulphate, and Calcium Cyanamid have met with the widest acceptance. Of these three, Sodium Nitrate at present is the highest priced when cost is reduced to cents per pound of nitrogen. It has the advantage of being immediately available to the plant the moment it enters the soil, since its nitrogen is already in the nitrate form. For this reason, many growers prefer it in those cases where the object of manuring is to stimulate the growth of plants which have been injured by flooding, or which, for some other reason, are backward. As a maintenance manure for regular use on manure areas it has one great disadvantage. It leaches readily from the soil, hence much of its value is lost if heavy rains occur soon after the material is applied. A second disadvantage, which fortunately is serious only in occasional cases, is that it contains sodium, a chemical which has an injurious effect upon the structure of certain clays, rendering them in time more impervious to water.

Ammonium Sulphate, which in comparison with Sodium Nitrate and Calcium Cyanamid has been used relatively little on banana farms, seems to be as efficient as the other two so far as growth and production are concerned. It has an advantage over Sodium Nitrate in that it does not leach readily from the soil, but this advantage is more than counterbalanced, in the opinion of many planters, by the fact that Ammonium Sulphate rapidly renders soils more acid.

Calcium Cyanamid—and it should be noted that the granular form called Aero Cyanamid is the only one to be used—is proving highly satisfactory and during the past two years has largely replaced Sodium Nitrate and Ammonium Sulphate on the banana farms of Central America and Jamaica. Its advantages are several: in the first place, it has no injurious effect upon soil structure or acidity, even when its use is continued year after year. In the second place, its nitrogen is not lost through leaching but remains in the soil until taken up by the plants; and in the third place, it is one of the most economical to use, partly because the original cost is lower than that of Sodium Nitrate and partly because larger quantities can be applied at one time with a longer interval between applications thus effecting a saving in labour.

Though not so prompt in its effect as Sodium Nitrate, Calcium Cyanamid has proved fully as good as other artificial manures so far as its total effect on growth and production is concerned. It keeps well in storage, is clean and easy to apply, and over a long period of time may have a desirable effect on certain clays, through the addition of lime which it carries. It must be applied to the ground somewhat more carefully than Sodium Nitrate. For best results it should be incorporated with the soil; where this is not feasible it should be scattered thinly over the surface in a band two or three feet wide, forming a half moon whose inner edge is not less than a foot and a half from the plant. No manure should be applied back of the plant; *i.e.* toward the centre of the mat, since it is obvious that there are no feeding roots in this area.

When Sodium Nitrate is used as a maintenance manure, it has been the practice in Honduras to give three to five applications per year, these to be four to six weeks apart during the season of light rains, which in that region is generally from May to October. An application usually consists of four ounces for each mature plant. Where the pruning programme calls for three plants per mat, each mat, therefore, gets 12 ounces of Sodium Nitrate per application. On certain Jamaican soils, recent experiments have indicated that it is preferable to use two ounces per plant at each application, but to repeat the applications monthly throughout the year.

Calcium Cyanamid can be applied at somewhat longer intervals—probably eight weeks at least—using three or four ounces per plant at each application. This manure contains 22 per cent. of nitrogen as opposed to 20 in Ammonium Sulphate and 16 in Sodium Nitrate. It is only fair to state in concluding this subject that further experience is required with these and other manures before their use can be placed on the soundest economical footing. It is particularly important that each planter study the individual needs of his own soils before embarking on a wholesale and expensive programme of manuring. There are few things which pay better returns than manures when intelligently used, and there are few things on which more money can be thrown away if their use is not based on sound fundamental knowledge.

Pruning.

I believe the French speak of this as the "Art of Pruning", an expression I have always fancied, for pruning is something which cannot be reduced to a few simple rules. There is as much art to it as there is science, and the man who does not use plenty of both will not get the most out of his farm.

Attempting to summarise the principles which in general, underlie this basically important practice, I would say that the objectives of pruning are (i) to maintain at all times the optimum plant population, *i.e.* the maximum number of mature plants consistent with the production of fruit of good quality, and (ii) to insure rapid sequence of crops through selecting, from time to time, those suckers best fitted through origin and situation to produce fruit, and protecting them from competition.

Obviously, when operating on a large scale with labourers, many of whom have had limited pruning experience, pruning practice must be as simple as possible if mistakes are to be kept at a minimum. For this reason, it is of material assistance to plan carefully in advance of planting, and adopt a spacing programme which will provide the optimum number of mature plants per acre by keeping a uniform number—usually two to four—plants per mat.

With this sound basis as a starting point, pruning consists primarily in saving the first good sucker which makes its appearance and removing others promptly so they will not compete. During the first year, of course, when the mat is being formed, more than one sucker must be saved if the programme calls for more than one plant per mat. Occasionally mats are started with the ultimate number of plants by using two or more heads to each. For reasons of economy, however, it is more common to plant one head only and develop from this as rapidly as possible the requisite number of plants.

On rich soils in moist climates pruning need not be done more than three or four times a year. This is the practice in several of the Central American banana regions. Accordingly as climate and soil become less favourable, however, the struggle for existence becomes more keen and plants destined for fruit production must be given all possible assistance by eliminating at an earlier stage the competition of plants surrounding them.

For this same reason—the reduction of competition—it is desirable to keep plants spaced within the mat as far apart as possible. This is particularly true during the first two or three years before the mat has opened up materially.

In Colombia, five or six prunings are given during the year. In Jamaica, the number is increased to eight or even ten. In the latter country, "Timed Pruning" is a subject of much discussion and debate. The object of this practice is to select annually suckers for the following year's crop with a view to having this crop mature before the latter part of August when the danger of loss from hurricanes becomes grave. Timed pruning is not wholly successful at best. It can only be practised with any hope of success on plantings less than three years old; and it is the belief of numerous experienced growers that it is preferable to select the first good, strong sucker which makes its appearance, without regard to whether or not this sucker meets its owner's idea of a plant that will fruit twelve months later. There must necessarily be a good deal of guess work about the time required for any given sucker, now two feet high (for example), to reach maturity and produce fruit.

In connection with pruning it is necessary to mention the subject of "water suckers", as they are known to banana men in English-speaking countries. Water suckers are plants which have been handicapped by an inadequate food supply. They are characterised by their broad leaves as opposed to the narrow sword-like leaves of the sword sucker. In other words, the water sucker is fitted by nature to lead an independent existence at an earlier stage of its career than the sword sucker. It is the practice in all banana growing regions to remove water suckers when pruning is done. This is sound, so long as there are sufficient sword suckers present to maintain the desired population of the mat. If this is not the case, and there is a water sucker present suitably situated in the mat, it should be saved, for it will ultimately reach mature size and its progeny will be normal sword suckers.

Irrigation.

As has been stated earlier in this paper, it may be said on general principles, that banana plants should have irrigation in regions where there is normally an annual dry season eight weeks or more in length. As a matter of fact, most banana regions in which irrigation is practised have dry seasons of three months or more. The south coast of Jamaica is an extreme case: in the district of St. Catherine near Kingston, irrigation is maintained throughout the year.

Irrigation systems as laid out for banana farms conform, in general, to standard irrigation practice, hence there is no need to discuss them in detail here. The method of applying water, however, varies somewhat from that used in regions like California, where water is scarce and cultural methods are intensive. Furrow irrigation, such as that practised in California citrus groves, is not known on banana farms in any country I have visited. At best the method may be termed a furrow-flood system; that is to say, water is taken from laterals by means of furrows of which one or two run between each two rows of bananas. With this assistance, the irrigator works his water by hand, leading it here and there with a shovel until ultimately the surface is adequately wetted. The furrow is then blocked off and the water turned into the succeeding one.

Frequency of application is varied somewhat to meet soil conditions. I think it may be said that the average frequency in the principal banana regions around the Caribbean is somewhere between three and four weeks, perhaps nearer the latter than the former. Deep, loamy soils can, in many cases, stand a four week cycle without suffering perceptibly. On the other hand, heavy clays need water in light doses every ten to fourteen days, while shallow soils with sand or gravel beneath them get too dry even on a ten day cycle.

A common feature of banana farms is a very irregular terrain. There are high spots which it is almost impossible to reach with irrigation water, and there are low spots which are almost certain to get too much. Under such conditions it is necessary, in order to wet as large a percentage of the surface as possible to use more water than would ideally be employed. Let us say, for example, that four acre inches of water is an adequate application for a certain area. In many cases, six or eight acre inches are used before the irrigator is satisfied that he has done a good job on the high spots.

I believe it will become more and more the practice to level the land for irrigation in advance of planting bananas. As a result of this, irrigation application of three to five acre inches of water—possibly about the right amount—will become more common in the future than they are at present.

The Crop.

Theoretically, a banana plantation with a population of 500 plants per acre should produce 500 bunches of fruit per acre per year. The well-known fact, that average yields per acre over areas of large size are rarely as high as 300 bunches has caused many a banana man to scratch his head and ask what becomes of the other 200. Losses occur from numerous causes: blowdowns, floods, droughts, failure to cut at the proper maturity, bruising or breakage at harvesting, and so forth. I believe it is safe to say that any experienced Central American banana man would be more than satisfied with a marketed crop of 300 bunches per acre, especially if these bunches are mostly of nine hands or more—let us say, with a count bunch ratio of 90.

That very few growers achieve such yields is more a reflection on their agricultural practices than an admission of losses beyond their control. For with the possible exception of Jamaica and Colombia, banana culture around the Caribbean

is by no means marked by such intensive methods as those which characterise, for example, citrus culture in any region where it is conducted on a large scale. Nevertheless, banana culture, as a branch of agricultural science, has made great strides during the past quarter of a century. I have attempted in this paper to point out some of these. With further study and the application of more intensive methods, yields can be increased it is believed, until the average is much nearer 300 count bunches per acre than it is to-day.

Though bananas are available throughout the year, the crop in any given area will show a tendency to peak at a certain season. The height of this peak seems to be correlated with climate: in an area with a well marked dry season, the crop peaks to a greater extent than in an area with fairly uniform rainfall throughout the year.

One more effect of climate upon the crop has already been mentioned: cool weather retards development of the fruit, as well as growth of the plant. During an unusually cool period, the grower may actually have trouble from fruit which matures on the tree before it reaches grade.

This brings us, in turn, to the subject of grade, one which is a never-ending source of discussion among banana men. Grade, defined in few words, is fullness or diameter of the individual banana. It should not be, but frequently is, confused with maturity, which is the physiological stage of development without regard to fullness or diameter. Maturity is correlated closely with the number of days the bunch has hung upon the plant. Under normal weather conditions, grade is also, but in cool weather, maturity can be attained and the fruit ripen without reaching grade.

Though it is customary to speak of grade as three-quarter, full three-quarter, and full, it has always seemed to me that there are, in reality, only two grades: European and American. It is the aim of banana men to cut fruit for the American market as full as possible. For the European market a different standard is used; here the grade must be definitely lighter or the fruit will not carry to Europe.

Summary.

What are the principal things which the banana grower, in the countries bordering on the Caribbean (and in the Islands) should keep in mind, if he wishes to farm successfully? I have attempted to sketch these briefly in the foregoing pages. Admittedly many points have been omitted, and time will change our conception regarding others. But in the light of present-day knowledge, I believe we can summarise the major requirements as follows:

1. The climate should be free from extremes; warm throughout the year, devoid of strong winds, and with light rains falling at frequent intervals. The nearer this can be approached, the better. Unfortunately, the ideal climate does not exist. Deficiencies of rainfall, however, can largely be overcome by irrigation.

2. The ideal banana soils are deep, fine sandy loams and clay loams. Soils which are underlaid with sand or gravel on the one hand, or impervious clay on the other, should be avoided if the surface layer of satisfactory soil is less than a foot and a half in depth. Clays, which are abundant in the tropics and of various kinds, can in some cases be farmed with highly satisfactory results if adequately drained, and if grass is kept out of the planting. In other cases they require occasional tillage; while in still others they do not yield satisfactory results under any system of farming which is economically feasible.

3. Drainage is the keynote of successful banana cultivation, in the great majority of banana regions, and is the feature which in past years has most frequently received inadequate attention. Where natural drainage does not keep the water table at all times three feet or more below the surface of the land, artificial drainage should be installed. In considering drainage, attention must be given to three things: first, outlet; second, surface run-off; and third, subsurface drainage required to keep the water table at the necessary depth.

4. Planting in itself is a simple operation, but much attention should be given in advance to spacing, with a view to providing optimum plant population in the mature farm. On rich soils in moist climates several sorts of propagating material may be used satisfactorily; on poorer soils in arid climates it is desirable that sound young entire heads, preferably from eight to twelve-foot sword suckers, be used.

5. In moist climates, the only cleaning required is periodic removal of broad leaved vegetation with the machete; in dry climates, on heavy soils, disk harrowing is sometimes necessary. A major objective is to keep grass out of the farm at all times; where this cannot be done by maintaining the proper balance of shade, it must be done with implements.

6. Artificial manures can profitably be used on many soils. In general, the element lacking is nitrogen; this can be supplied through Calcium Cyanamid, or other manures. Before investing heavily in manures, the planter should satisfy himself that his soils require it. The only way to do this is through carefully recorded experiments.

7. Pruning must be done a minimum of three times a year in moist climates; a maximum of ten times in arid climates on poor soils. The objects are: to maintain the optimum plant population at all times, and to maintain rapid sequence of crops through selecting the strongest suckers which are properly placed and protecting them from competition by prompt removal of those not destined for fruit production.

8. Irrigation can profitably be used in most cases, if a normal dry season of more than eight weeks must be expected. Naturally, much depends on availability and cost of water. Frequency of application averages three to four weeks during the irrigating season, with a minimum of about ten days on very heavy or very light soils. The ideal application is about four acre inches.

HAND STRIPPING OF SEED CANE.

By Arthur H. Rosenfeld.
(*Consulting Technologist for Sugar Cane, Cairo, Egypt.*)

It is a well known fact that when a cane leaf dries it becomes stiff and parchment-like. It would appear, therefore, that the young shoots from planted cane would reach the surface of the ground more easily if they did not have to perforate this dry leaf-covering. At the same time, there can be no doubt that in time of drought this impermeable covering can do good service in retaining moisture in the seed or sprout and, to a certain extent, preventing its drying out.

Two Theories Maintained.

There are, accordingly, two opposite theories regarding the question of "stripping" cane by hand before planting, particularly in those countries where whole canes are used for seed. Certain progressive planters pay every year for having their cane handstripped in preparing their seed, while others, in the same neighbourhood, not only consider such expenditure a waste of money, but insist that the treatment of the seed cane in this manner is liable to prejudice results in dry germinating seasons.

The writer a number of years ago started at the Tucuman Sugar Experiment Station a series of experiments in the hope of throwing some light on this question. The preparation, planting, irrigation and cultivation of the two series of plants in the experiments were absolutely identical, one set of plots being planted in Louisiana Purple cane prepared without stripping, as is the usual custom in Tucuman, and the other with cane from the same source which was hand-stripped before being planted. Two crops were obtained from the original planting. The results from the two methods of applying the seed were so nearly identical that it was decided to start a second series of experiments along the same lines. This series was practically a duplicate of the first one, the same variety of cane being employed, and the details of preparation, cultivation, &c., being almost identical.

The results from the four crops are given in the accompanying table in metric tons of cane per hectare :

Cane.	Unstripped tons per ha.	Stripped tons per ha.
First Series.		
Plant	29.07	29.42
Ratoon	47.10	46.29
Second Series.		
Plant	15.33	17.60
Ratoon	22.20	22.80
Yearly average ...	28.43	29.03

One hectare = 2.471 acres.

An average annual difference in yield of around one-half ton of cane per hectare would be well within the permissible limits of experimental error, and the results from the four crops fail to indicate any advantage from hand stripping the seed—certainly not enough to pay for the cost of the process, which must therefore be considered an unremunerative one. Incidentally, it should be mentioned that the average weight of stalk was practically the same in both series of experiments, while the chemical analyses did not reveal any outstanding effect of the stripping on the sugar content or the purity of the juices. It would appear, therefore, that most of the young shoots reach the surface in a reasonable time notwithstanding the toughness of the dry adhering leaf sheaths.

CHEMICAL NOTES.

(*Compiled by the College Department of Chemistry and Soil Science.*)

Soil Nitrogen.*

The nitrogen supply of the soil is of particular importance in India, where a tropical climate and cultivation over very long periods without addition of manures or fertilisers have combined to produce a general nitrogen deficiency. In general, there is less nitrogen in tropical than in temperate soils, but a greater proportion of the total nitrogen is in a form available to plants. In India, the main problem might be described as the immobilisation against leaching, rather than the mobilisation for plants, of soil nitrogen. Much attention is being paid to methods of stimulating natural processes of nitrogen fixation, and to the nature of nitrogen compounds in organic manures. Nitrogen added to the soil in inorganic fertilisers has the disadvantage of impermanence, and the part played in the nitrogen cycle by the carbon contained in organic manures has been the subject of several studies.

Evidence has been adduced to prove that there is more nitrogen fixation in soils mixed with energy-providing materials such as carbohydrates,

* Copied from *Reports of the Progress of Applied Chemistry*, Society of Chemical Industry, England, Vol. XXIV, 1939; Section on "Soils and Fertilizers" by G. V. Jacks. The references to literature have been omitted.

cellulose, and fats in sunlight or artificial light than in the dark, although *Azotobacter* numbers are much greater in dark than in light. It is concluded that light is actually utilised in an endothermic chemical reaction of nitrogen fixation analogous to photosynthesis in plants. Oxidation of carbohydrates is said to be capable of inducing photochemical fixation of nitrogen in the absence of micro-organisms but in the presence of suitable photocatalysts. Catalysts, among which the oxides of titanium, zinc, cadmium, aluminium, silicon, and magnesium are the most active, can also induce the oxidation of ammonia to nitrate in the presence of sunlight, short waves being particularly efficient. Free ammonia has been obtained by exposing amino-acids to sunlight in presence of humic acid.

The natural maintenance of soil fertility in humic tropical conditions has been explained on the basis of these conclusions in which, in the absence of photochemical nitrogen fixation, the rapid mobilisation of nitrogen and excessive leaching should reduce the nitrogen content of soils to vanishing point.

* * *

Manganese Deficiency for Citrus in California.

Many investigators of plant physiology have shown that a deficiency of manganese causes abnormal development of plant foliage. Camp and Reuther (1) have described deficiency symptoms on orange and grapefruit trees in Florida soils, while Taylor and Burns (2) have reported them on oranges in New Zealand. Haas (3) has described symptoms on citrus grown in nutrient cultures. Extension and clarification of descriptions of deficiency symptoms on citrus, especially on lemon trees, have resulted from recent studies by Chapman, Liebig and Parker (4). For many years investigators (5) in California have applied manganese to soil and to leaves of citrus trees in an effort to diagnose the cause of subnormal tree behaviour. Results of concluded trials are not definite. Recently, however, responses to manganese treatments have been obtained on citrus trees in the Santa Clara River valley in southern California. Certain vigorous lemon trees in that area normally produce young leaves which are pale green in colour with sharply defined green midrib and veins. Very pale green blotches, about 3 mm. in diameter, appear at random in inter-veinal spaces. Occasional terminal leaves are devoid of green colour. Old leaves are frequently affected with a faint mottling. Spraying of the leaves of one limb of one of these trees with a concentrated solution of manganese sulphate in August, 1937, resulted in severe injury and repression of new growth. Some new growth appeared on this limb during 1939 however, and in August was considered normal. No improvement was noticed elsewhere. Liberal applications of manganese sulphate in 1937 to the soil about other trees in this area have not yet caused improvement.

In July, 1939, we inspected a lemon orchard in the same valley, in which the trees are subject to premature "decline". Recent foliage of trees in the beginning stages of decline showed typical symptoms of manganese deficiency, as recently determined (4). Analysis of such leaves indicated a low manganese content. Treatment of several trees on 2nd August, 1939, by injection with C.P. manganese chloride solutions and crystals (3-8 gm. per 3-inch limb), as well as by spraying with 1.25 to 1.5 per cent. solutions of this material, resulted in greening of leaves within 15 days. The sprays caused slight burning of tender leaves. Subsequently, several hundred trees were treated by spraying and injection with corresponding effects. The results indicate a deficiency of manganese for citrus trees in this area. The relations of this condition to premature decline of fruit trees may be of importance.—(*Science*, Vol. XCI, No. 2355, pp. 169-70, 1940.)

E. R. PARKER.
H. D. CHAPMAN.
R. W. SOUTHWICK.

University of California
Citrus Experiment Station,
Riverside, California.

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Soils and Fertilizers in Puerto Rico.—*By Bernardo G. Capo.*

(Paper read before the Association of Sugar Technologists of Puerto Rico, 1939.)

From observations, analyses and tests made to date, it is concluded that practically all of the soils of Puerto Rico are deficient in nitrogen in a form assimilable by plants. The majority of the humid soils of the island are also deficient in assimilable phosphorus, and a large number of these soils require applications of lime carbonate to put them into condition to produce maximum yields. A large number of Puerto Rican soils in both the humid and the arid zones give no statistically significant response to applications of potash fertilizer. The author advocates the policy of ascertaining what plant nutrients are present in the soil in only small quantities, and then applying sufficient quantities of these nutrients to make up the deficiency. This is a more rational procedure than to apply the same fertilizer formula to all soils without actual knowledge of the present condition of these soils. (*The International Sugar Journal*, Vol. XLII, No. 500, pp. 293-294, 1940).